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APPLICATION NO.	FILING DATE	FIRST NAMED INVENTOR	ATTORNEY DOCKET NO.	CONFIRMATION NO.
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Hans-Joachim Barth

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EXAMINER

VELASQUEZ, VANESSA T

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1793

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PAPER

Please find below and/or attached an Office communication concerning this application or proceeding.

The time period for reply, if any, is set in the attached communication.

Office Action Summary	Application No. 10/512,016	Applicant(s) BARTH ET AL.	
	Examiner Vanessa Velasquez	Art Unit 1793	

-- The MAILING DATE of this communication appears on the cover sheet with the correspondence address --

Period for Reply

A SHORTENED STATUTORY PERIOD FOR REPLY IS SET TO EXPIRE 3 MONTH(S) OR THIRTY (30) DAYS, WHICHEVER IS LONGER, FROM THE MAILING DATE OF THIS COMMUNICATION.

- Extensions of time may be available under the provisions of 37 CFR 1.136(a). In no event, however, may a reply be timely filed after SIX (6) MONTHS from the mailing date of this communication.
- If NO period for reply is specified above, the maximum statutory period will apply and will expire SIX (6) MONTHS from the mailing date of this communication.
- Failure to reply within the set or extended period for reply will, by statute, cause the application to become ABANDONED (35 U.S.C. § 133). Any reply received by the Office later than three months after the mailing date of this communication, even if timely filed, may reduce any earned patent term adjustment. See 37 CFR 1.704(b).

Status

- 1) ☒ Responsive to communication(s) filed on 19 April 2010.
- 2a) ☐ This action is **FINAL**. 2b) ☒ This action is non-final.
- 3) ☐ Since this application is in condition for allowance except for formal matters, prosecution as to the merits is closed in accordance with the practice under *Ex parte Quayle*, 1935 C.D. 11, 453 O.G. 213.

Disposition of Claims

- 4) ☒ Claim(s) 12-17, 20-23 and 25 is/are pending in the application.
- 4a) Of the above claim(s) _____ is/are withdrawn from consideration.
- 5) ☐ Claim(s) _____ is/are allowed.
- 6) ☒ Claim(s) 12-17, 20-23 and 25 is/are rejected.
- 7) ☐ Claim(s) _____ is/are objected to.
- 8) ☐ Claim(s) _____ are subject to restriction and/or election requirement.

Application Papers

- 9) ☐ The specification is objected to by the Examiner.
- 10) ☐ The drawing(s) filed on _____ is/are: a) ☐ accepted or b) ☐ objected to by the Examiner.
Applicant may not request that any objection to the drawing(s) be held in abeyance. See 37 CFR 1.85(a).
Replacement drawing sheet(s) including the correction is required if the drawing(s) is objected to. See 37 CFR 1.121(d).
- 11) ☐ The oath or declaration is objected to by the Examiner. Note the attached Office Action or form PTO-152.

Priority under 35 U.S.C. § 119

- 12) ☐ Acknowledgment is made of a claim for foreign priority under 35 U.S.C. § 119(a)-(d) or (f).
- a) ☐ All b) ☐ Some * c) ☐ None of:
1. ☐ Certified copies of the priority documents have been received.
 2. ☐ Certified copies of the priority documents have been received in Application No. _____.
 3. ☐ Copies of the certified copies of the priority documents have been received in this National Stage application from the International Bureau (PCT Rule 17.2(a)).

* See the attached detailed Office action for a list of the certified copies not received.

Attachment(s)

- | | |
|--|---|
| 1) <input checked="" type="checkbox"/> Notice of References Cited (PTO-892) | 4) <input type="checkbox"/> Interview Summary (PTO-413)
Paper No(s)/Mail Date. _____ |
| 2) <input type="checkbox"/> Notice of Draftperson's Patent Drawing Review (PTO-948) | 5) <input type="checkbox"/> Notice of Informal Patent Application |
| 3) <input type="checkbox"/> Information Disclosure Statement(s) (PTO/SB/08)
Paper No(s)/Mail Date _____ | 6) <input type="checkbox"/> Other: _____ |

DETAILED ACTION

Continued Examination Under 37 CFR 1.114

1. A request for continued examination under 37 CFR 1.114, including the fee set forth in 37 CFR 1.17(e), was filed in this application after final rejection. Since this application is eligible for continued examination under 37 CFR 1.114, and the fee set forth in 37 CFR 1.17(e) has been timely paid, the finality of the previous Office action has been withdrawn pursuant to 37 CFR 1.114. Applicant's submission filed on 4/19/2010 has been entered.

Status of Claims

Claims 1-11, 18, 19, 24, and 26 are canceled. Currently, claims 12-17, 20-23, and 25 are pending and presented for examination on the merits. Of the pending claims, claims 1, 23, and 25 are independent.

Status of Previous Rejections Under 35 USC § 112

The previous rejections of claims 18 and 25 under the first paragraph of 35 U.S.C. 112 are withdrawn in view of the amendments to the claims.

Claim Rejections - 35 USC § 112, First Paragraph

2. The following is a quotation of the first paragraph of 35 U.S.C. 112:

The specification shall contain a written description of the invention, and of the manner and process of making and using it, in such full, clear, concise, and exact terms as to enable any person skilled in the

Art Unit: 1793

art to which it pertains, or with which it is most nearly connected, to make and use the same and shall set forth the best mode contemplated by the inventor of carrying out his invention.

3. Claims 12-17, 20-23, and 25 are rejected under 35 U.S.C. 112, first paragraph, as failing to comply with the written description requirement. The claims contain subject matter which was not described in the specification in such a way as to reasonably convey to one skilled in the relevant art that the inventors, at the time the application was filed, had possession of the claimed invention. Specifically, there is no support in the specification for the limitations in claims 12, 23, and 25 that recite that the second grain size is "enlarged exclusively" compared to the first grain size. There is also no support in the specification for the limitation in claim 14 that recites that the primary and secondary interconnects are exclusively lengthened in the direction of movement in the thermal region. Claims 13, 15-17, and 20-22 are likewise rejected for being dependent on rejected base claims.

Claim Rejections - 35 USC § 112, Second Paragraph

4. The following is a quotation of the second paragraph of 35 U.S.C. 112:

The specification shall conclude with one or more claims particularly pointing out and distinctly claiming the subject matter which the applicant regards as his invention.

5. Claim 14 is rejected under 35 U.S.C. 112, second paragraph, as being indefinite for failing to particularly point out and distinctly claim the subject matter which applicant regards as the invention. First, the claim recites that "the movement of the thermal region is carried out ... such that the interconnect in the primary direction and the interconnect in the secondary direction are exclusively lengthened in the direction of movement of the thermal region." As a matter of technical accuracy, it is believed that

Art Unit: 1793

the grains, not the interconnects themselves, are lengthened as a result of the movement of the thermal region. Second, the claim requires that the thermal region move in a direction that is 45 degrees relative to the directions of the primary and secondary directions. However, this direction is contradictory to claim 12, the independent claim on which claim 14 depends, because claim 12 states that the thermal region is moved in the interconnect and parallel to the seed layer that bounds the interconnect. It is unclear how the thermal region can move both parallel (zero degrees) and at a 45 degree angle to the interconnect simultaneously.

Claim Rejections - 35 USC § 103

6. The following is a quotation of 35 U.S.C. 103(a) which forms the basis for all obviousness rejections set forth in this Office action:

(a) A patent may not be obtained though the invention is not identically disclosed or described as set forth in section 102 of this title, if the differences between the subject matter sought to be patented and the prior art are such that the subject matter as a whole would have been obvious at the time the invention was made to a person having ordinary skill in the art to which said subject matter pertains. Patentability shall not be negated by the manner in which the invention was made.

7. The factual inquiries set forth in *Graham v. John Deere Co.*, 383 U.S. 1, 148 USPQ 459 (1966), that are applied for establishing a background for determining obviousness under 35 U.S.C. 103(a) are summarized as follows:

1. Determining the scope and contents of the prior art.
2. Ascertaining the differences between the prior art and the claims at issue.
3. Resolving the level of ordinary skill in the pertinent art.
4. Considering objective evidence present in the application indicating obviousness or nonobviousness.

8. This application currently names joint inventors. In considering patentability of the claims under 35 U.S.C. 103(a), the examiner presumes that the subject matter of

Art Unit: 1793

the various claims was commonly owned at the time any inventions covered therein were made absent any evidence to the contrary. Applicant is advised of the obligation under 37 CFR 1.56 to point out the inventor and invention dates of each claim that was not commonly owned at the time a later invention was made in order for the examiner to consider the applicability of 35 U.S.C. 103(c) and potential 35 U.S.C. 102(e), (f) or (g) prior art under 35 U.S.C. 103(a).

9. Claims 12-14, 16, 17, 20-23, and 25 are rejected under 35 U.S.C. 103(a) as being unpatentable over Shimizu et al. (US 6,242,808 B1) in view of Fan et al. (US 4,309,225), and further in view of Jiang et al. ("Line Width Dependence of Copper Resistivity," *IEEE*).

Regarding claims 12, 23, and 25, Shimizu et al. teach a method of laying copper wiring (metal interconnect) in a semiconductor device (col. 2, lines 24-27). Copper is a metal with relatively low electrical resistivity (col. 1, lines 46-53). The method includes forming a hole **5**, layering the hole with a barrier layer **6**, coating the barrier layer **6** with a seed layer **7**, and filling the hole with the barrier layer and seed layer with copper conductive layer **8** (FIGS. 1A-1C; col. 4, lines 10-40). As seen in FIG. 1B, for example, the conductive layer **8** (copper metal interconnect) is bound on three sides, two of them opposite to one another, by seed layer **7**. It is known in the art that copper wirings and the layers on which they rest are relatively small or thin in size (finely patterned) (col. 1, lines 54-67 to col. 2, lines 1-9; col. 4, lines 1-33).

Art Unit: 1793

Shimizu et al. teach subjecting the copper wiring to a heat treatment in order to recrystallize the seed layer and conductive layer and to eliminate the interface between them (col. 5, lines 11-14; col. 7, lines 25-27). The heat treatment produces grains that are enlarged compared to the grains prior to heat treatment (see FIGS. 3A and 3B). Shimizu et al., however, do not disclose applying the heat treatment in the particular manner described in the claims. Fan et al. teach a method of crystallizing amorphous and partially crystalline material (e.g., metals) by scanning a beam of energy (locally delimited thermal region) over the amorphous material (abstract). The method is advantageous because it can be carried out in the solid state (i.e., it does not require the material to be melted, resulting in smoother smooth surfaces), it allows for the use of relatively high scanning rates than previously applied, and it produces thermal gradients that produce grains that are larger and better aligned (col. 3, lines 1-18; col. 13, lines 39-56). Both Fan et al. and Jiang et al. teach that large grains promote improved electrical conductivity of semiconducting material and copper, respectively (Fan et al., col. 1, lines 20-35; Jiang et al., "Results and Discussion," first paragraph, "Conclusions" paragraph). Thus, it would have been obvious to one of ordinary skill in the art to have incorporated the scanning crystallization method of Fan et al. in the method of Shimizu et al. because said crystallization method would enhance the recrystallization heat treatment method of Shimizu et al. by forming copper wiring that has optimum electrical conductivity.

Regarding claims 13 and 23, Shimizu et al. and Fan et al. are silent as to any specific dimensions of the copper wiring. However, copper wiring with dimensions on

Art Unit: 1793

the order of less than 0.2 microns is well known (Jiang et al., "Abstract," Fig. 5). Smaller dimensions would allow the density of copper wiring to increase per area of device, allowing devices to be miniaturized. Therefore, it would have been obvious to one of ordinary skill in the art to have patterned the copper wiring of Shimizu et al. to be less than 0.2 microns in size in order to decrease the size of electrical devices utilizing circuitry with copper wiring.

Still regarding claim 25, Fan et al. teach that the scan rate is determined by the "dwell time" (duration of the laser on the surface of the sample) (col. 5, lines 16-19), which implicitly affects the extent to which the sample is crystallized and the size to which the grains coarsen. Therefore, it would have been obvious to one of ordinary skill in the art to have optimized the laser scan rate of Shimizu et al. in order to effect a desired degree of crystallinity and coarsening. Furthermore, this optimization would not be considered inventive or even burdensome, as Fan et al. clearly teach that scan rates may easily be manipulated, requiring no more than routine skill in the art (col. 5, lines 6-10; also MPEP § 2144.05).

Regarding claim 14(a), Shimizu et al. in view of Fan et al. do not teach copper wiring arranged such that the wiring is spatially arranged perpendicular to one another. Jiang et al. show that such an arrangement is well known in the art (Figs. 1(a)-1(c)). It is well established that shape is not a basis for patentability, absent evidence demonstrating the criticality of the shape (MPEP § 2144.04(IV)(B)).

Regarding claim 14(b), Shimizu et al. in view of Fan et al. and Jiang et al. do not teach moving the energy beam 45 degrees to the direction of the primary and

Art Unit: 1793

secondary interconnects. Fan et al. teach that the direction of scanning may be modified by moving the substrate to be crystallized upon a stage that has the capabilities of moving in the x, y, and/or z directions each independently and/or simultaneously in any combination in order to produce a desired scan rate and pattern (col. 4, lines 67-68 to col. 5, lines 1-10). It would have been obvious to one of ordinary skill in the art to have modified the scan angle in the process of Shimizu et al. in view of Fan et al. in order to effect a particular pattern of recrystallization and to produce a desired alignment of the enlarged grains formed.

Regarding claims 16 and 17, Fan et al. teach that the energy beam may take on the shape of a slit with an aspect ratio greater than 10 (fanned-out, strip-type) (col. 4, lines 33-36, 50-54).

Regarding claim 20, Shimizu et al. and Jiang et al. teach that damascene methods are conventional in forming copper wiring (Shimizu et al., col. 1, lines 60-65; Jiang et al., "Experimental" and "Conclusions" paragraphs).

Regarding claims 21 and 22, Shimizu et al. teach that a temperature of at least 300°C is sufficient to recrystallize the copper metal (col. 7, lines 25-27). Recrystallization should take place under an atmosphere of argon and hydrogen to prevent oxidizing the copper (protective atmosphere) or under vacuum (col. 7, lines 19-23).

10. Claim 15 is rejected under 35 U.S.C. 103(a) as being unpatentable over Shimizu et al. (US 6,242,808 B1) in view of Fan et al. (US 4,309,225) and Jiang et al. ("Line

Art Unit: 1793

Width Dependence of Copper Resistivity," *IEEE*), as applied to claim 12 above, and further in view of Higuchi et al. (JP 61-30027, English abstract).

Regarding claim 15, Shimizu et al. in view of Fan et al. and Jiang et al. do not explicitly teach repeating the movement of the thermal region. JP 61-30027, issued to Higuchi et al. and drawn to a process of recrystallizing semiconductors using an electron beam and heating lamp, teaches repeating the recrystallization process for the purpose of recrystallizing the entire sample (English abstract). Therefore, it would have been obvious to one of ordinary skill in the art to have applied the act of repetition, as taught by Higuchi et al., to the scanning step of Shimizu et al. in view of Fan et al. and Jiang et al. in order to ensure that the entire surface area of the copper wiring is recrystallized.

Response to Arguments

11. Applicant's arguments have been considered but are moot in view of the new grounds of rejection.

Conclusion

No claims are allowable.

Any inquiry concerning this communication or earlier communications from the examiner should be directed to Vanessa Velasquez whose telephone number is 571-270-3587. The examiner can normally be reached on Monday-Friday 9:00 AM-6:00 PM ET.

Art Unit: 1793

If attempts to reach the examiner by telephone are unsuccessful, the examiner's supervisor, Roy King, can be reached at 571-272-1244. The fax phone number for the organization where this application or proceeding is assigned is 571-273-8300.

Information regarding the status of an application may be obtained from the Patent Application Information Retrieval (PAIR) system. Status information for published applications may be obtained from either Private PAIR or Public PAIR. Status information for unpublished applications is available through Private PAIR only. For more information about the PAIR system, see <http://pair-direct.uspto.gov>. Should you have questions on access to the Private PAIR system, contact the Electronic Business Center (EBC) at 866-217-9197 (toll-free). If you would like assistance from a USPTO Customer Service Representative or access to the automated information system, call 800-786-9199 (IN USA OR CANADA) or 571-272-1000.

/Vanessa Velasquez/
Examiner, Art Unit 1793

/Scott Kastler/
Primary Examiner, Art Unit 1793